D0 tracking in disks

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- Why disks ?
- D0 silicon tracker
- Occupancies
- Tracking issues
- Performance
- Conclusions

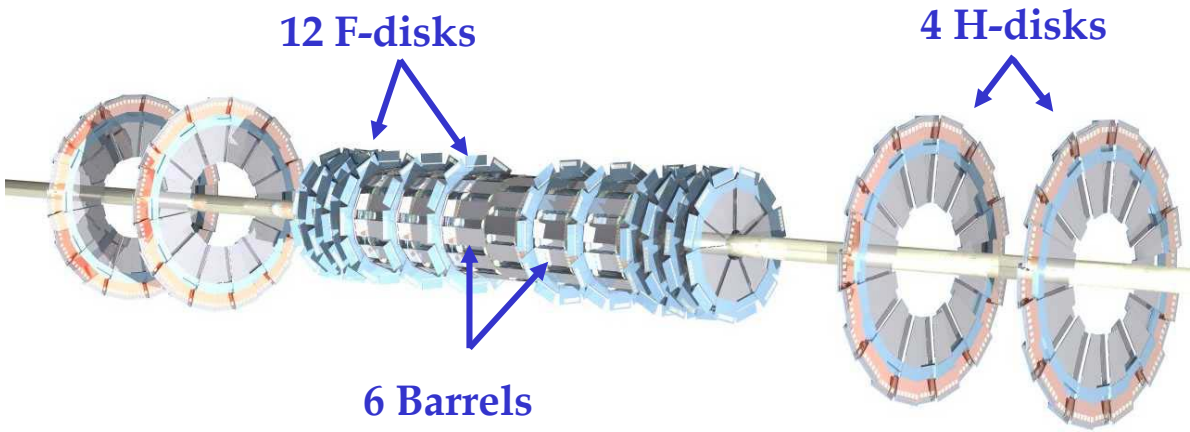
Why disks ?

- at high θ angles (> 45°) tracking with detectors parallel to the beam axis becomes problematic:
  - a lot of material
  - very long clusters on the stereo side
- want to add detectors with measuring planes at small angles w.r.t. incident tracks
  - usually use disks perpendicular to the beam axis
  - other designs are known (e.g. “umbrellas”)

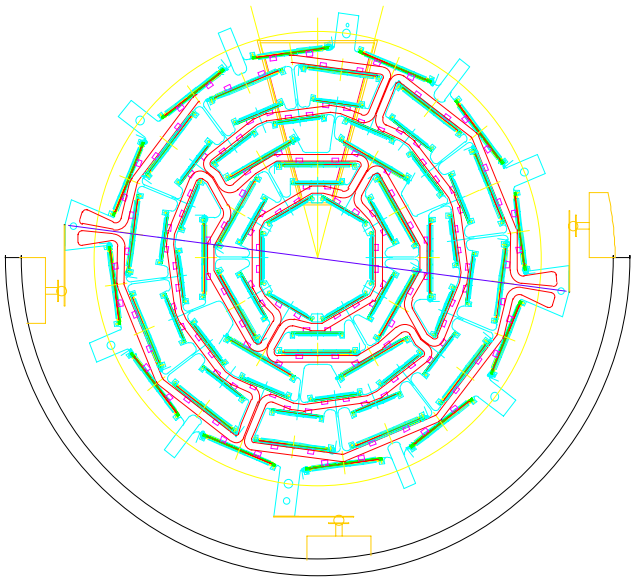
D0 tracker

- D0 vertexing/tracking detector (Silicon Microstrip Tracker, SMT) has some unique features:
  - barrel part is short (±38 cm) compared to the z beam spot size (σ=30 cm), so tracking in disks is crucial
  - disks are partially embedded between barrels, cannot really separate tracking in barrels and disks
  - pattern recognition at high $|\eta|$ has to be done entirely in SMT, without any external support

Silicon Microstrip Tracker



Multi-layer barrel cross-section

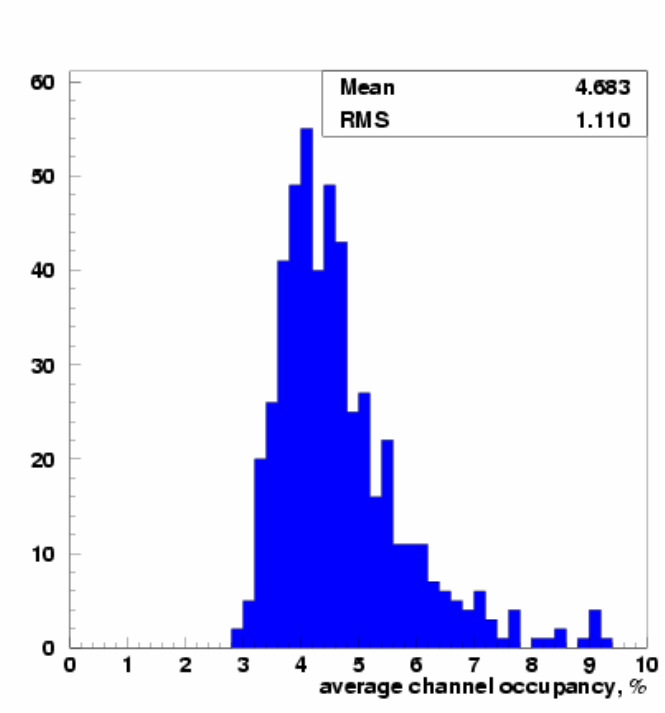


	Barrels	F-disks	H-disks
	Double and single sided	**Double sided**	**Single sided**
Stereo angle	**0°, 2°, 90°**	**±15°**	**±7.5°**
Channels	**~400K**	**~250K**	**~150K**
Inner radius	**2.7 cm**	**2.6 cm**	**9.5 cm**
Outer radius	**9.4 cm**	**10.5 cm**	**26 cm**

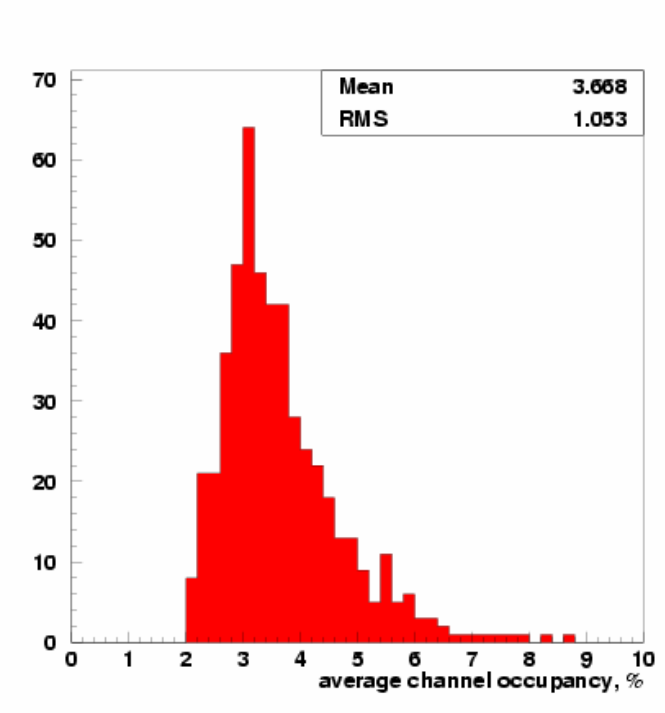
3m^2 of silicon

Occupancy in disks

- occupancy in terms of read-out channels is at the level of few per cent, dominated by noise



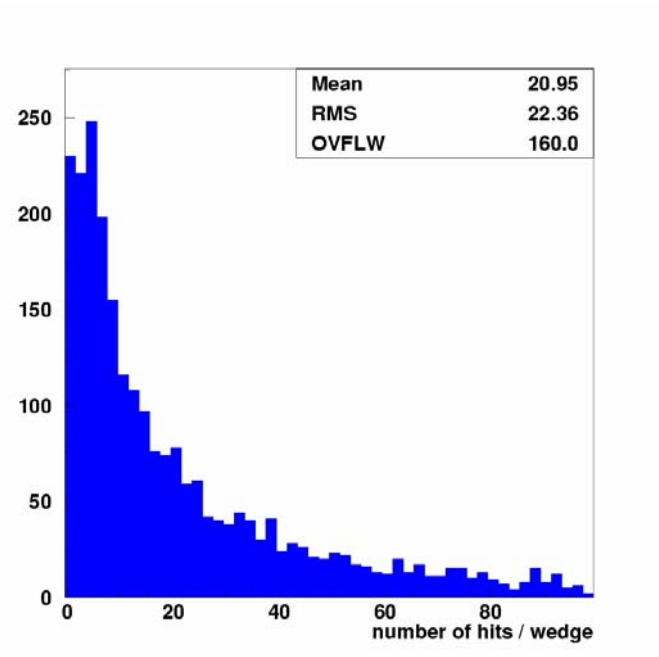
f-disks, p-side



f-disks, n-side

Occupancy in disks (2)

- average occupancy in terms of stereo matched hits is ~20 hits / detector, with long tails



Run 166866

Instantaneous luminosity: 28E30 $cm^{-2}s^{-1}$

Rate to tape: 41 Hz

Strip direction

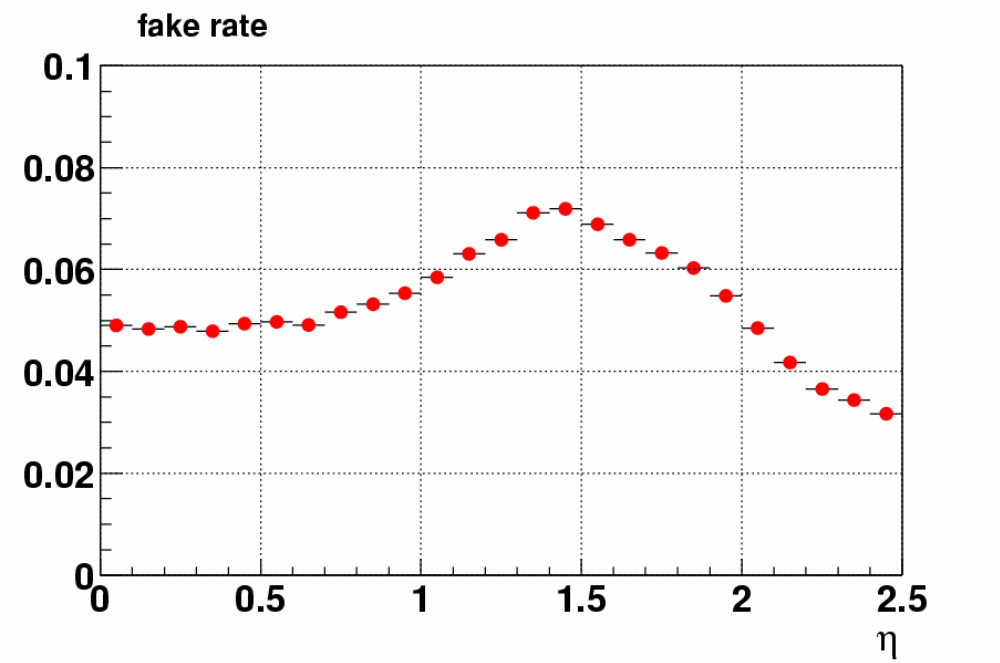
- for the pattern recognition, the best option is strips on one side pointing to the beam:
  - this is a (z,φ) measurement
  - for tracks originating from (0,0), $\varphi = kz$
- other options do not provide a meaningful measurement – just an arbitrary line in space
  - at least to initialize the tracking, always have to combine two views, and run into combinatorics !
- for barrels, small stereo angle means just worse z resolution
- for disks, it affects the pattern recognition – have to allow for wrong order of point radii !

Pattern recognition in disks

- tracking in barrels is straightforward
  - for barrels, (r,φ) and (z,θ) track parameters nicely decouple, allowing for powerful global pattern recognition methods (Hough transform, histogramming approach)
  - one can begin with (r,φ) tracks and add z later, when the picture is already cleaned up
- it is different for disks
  - 2d disk hits do not have neither precise r nor precise φ measurement, and there are lots of fake hits due to the combinatorics because of a high stereo angle
  - 1d disk hits can only be used at later tracking stages, when the track candidate is already formed

Track fake rate

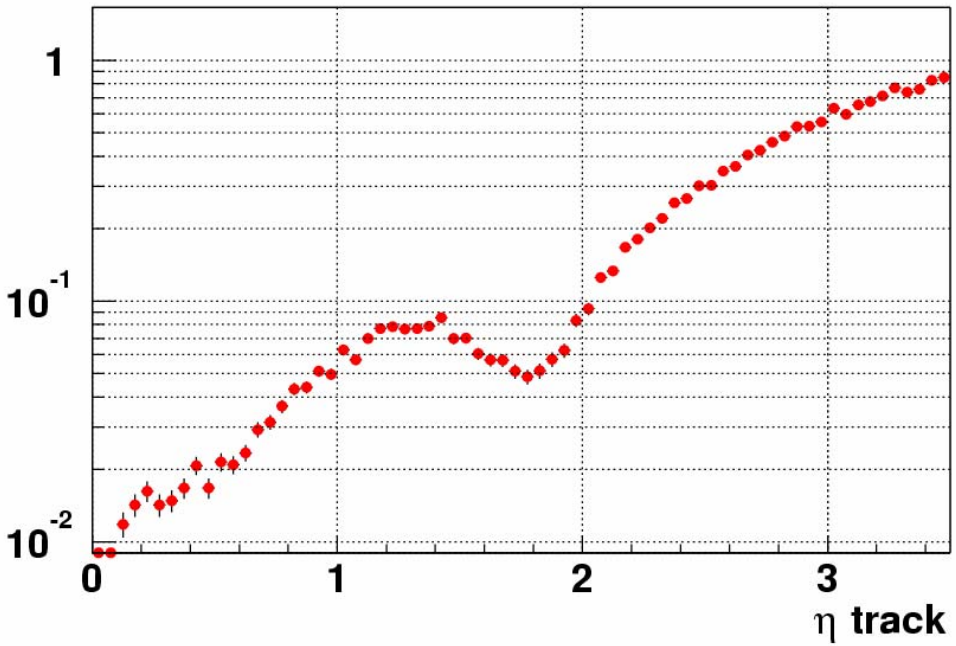
- fake rate is a problem since there are so few points
  - understand your χ^2
  - remove tracks with missing layers
  - drop tracks without neighbors in z



shown: fake rate in 40 GeV QCD jets (MC)

Tracking performance

- disks are important for reconstructing high quality tracks with at least 2 SMT hits

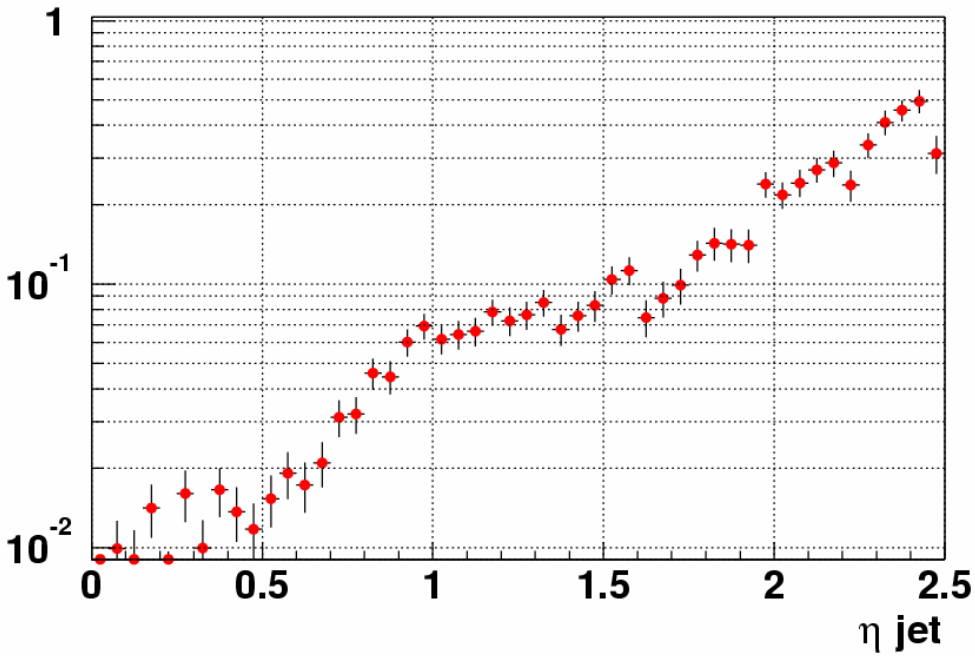


shown: ratio of the number of tracks with ≥2 SMT hits and <2 SMT barrel hits to the total number of tracks with ≥2 SMT hits

Sample: EM QCD (data)

b-tagging using tracks in disks

- b-tagging at $|\eta|>1$ increases by >7% when using tracks with disk hits (b-tagging algorithms require tracks with ≥2 SMT hits)



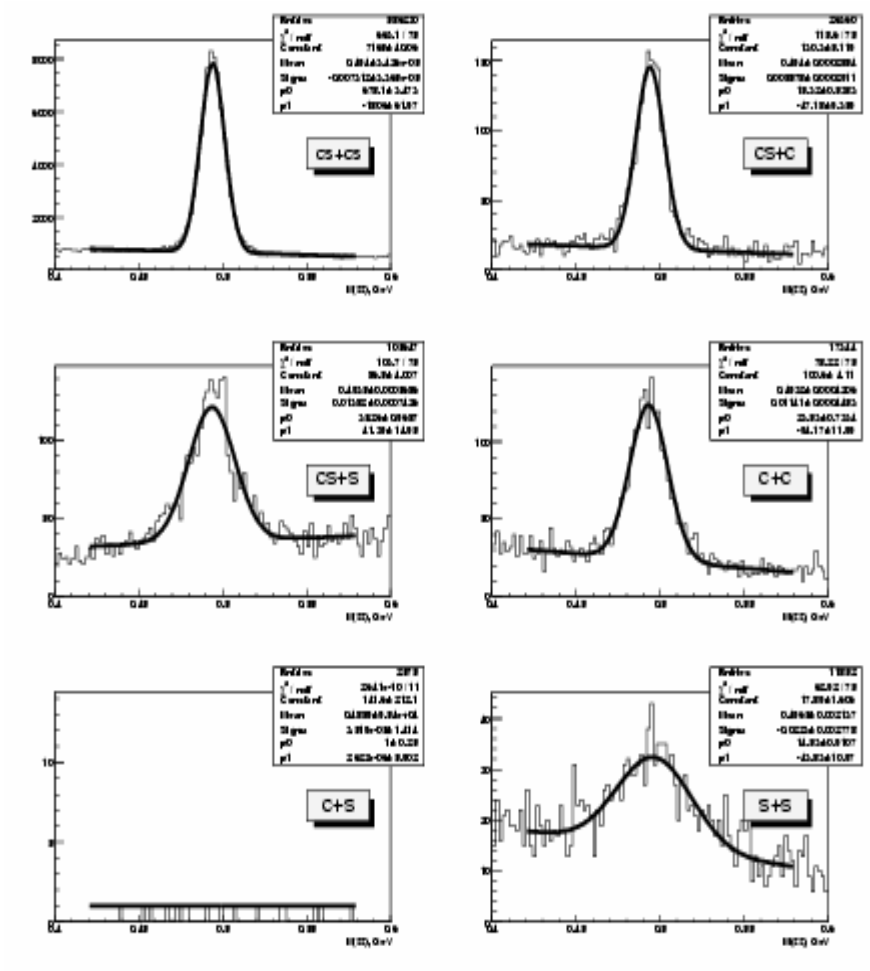
shown: $(N_b - N_b^{bar}) / N_b$

N_b = number of tagged b-jets
N_b^{bar} = number of tagged b-jets not using tracks with <2 SMT barrel hits

Sample: W+bbx (MC)

Reconstruction of physical objects

- Example: K_S made of tracks with both CFT and SMT hits (CS), CFT-only tracks (C) or SMT-only tracks (S) (data)
  - resolution is ~3 times worse for S+S compared to CS+CS



Conclusions

- Tracking in disks is possible and useful
- It is a good idea to design a tracking device having in mind the pattern recognition aspects